CANADA

DEPARTMENT OF ENERGY, MINES AND RESOURCES

MINES BRANCH

OTTAWA

Fuels Research Centre

Divisional Report FRC 73/1

INTERIM REPORT ON MICROSCOPIC EXAMINATION OF PYRITES AND PETROGRAPHIC ANALYSIS OF FLOAT AND SINK FRACTIONS OF LINGAN MINE COAL

by

B. N. Nandi and D. S. Montgomery

27pp

January 1973

GRAVITY SEPARATION

1. Float on Specific gravity 1.25. The sulphur content is 0.67 %. The pyrites observed in the microscope are round and the diameter is about 10 - 15 microns. These pyrites are mostly associated with exinite. Figure 1 and 2.
2. Float on Specific gravity 1.30. The sulphur content is 0.92 %. The pyrites in this fraction consist of both small and large particle size of very irregular shape and associated with vitrinite and semifusinite. The particle size varies from 20 to 2 microns. See Figure 3 and 4.
3. Float on Specific gravity 1.35. The sulphur content is 3.0 %. Development of larger particle of pyrites was observed in this fraction. These pyrites have very irregular shapes and sizes with fissures and cracks. (These are probably of epigenitic origin). (See Fig. 5).
4. Float on Specific gravity 1.40. Sulphur content is 4.87 %. High concentration of fine concretions in a vitrain (Figure 6) was observed. These fine grains are mostly associated with vitrain of coal. Other structure which looks like jaw or Shell type are possibly formed by replacement. (Figure 7 and 8).
5. Float on Specific gravity 1.45. Sulphur content 6.90 %. In this fraction several different structures of pyrites were observed. Finely disseminated granular pyrites and large pyritic concretion were observed in Figure 9 (tungsten light) and Figure 10 (Fluorescence light). In Figure 11, two large black lenticular structures were observed. These black lenticular pores were not filled up with exinitic material because this dark and black space did not fluoresce as shown in Figure 12. Whereas the circular and oblong shaped black cracks (Figure 13) showed usual characteristic deep brownish to yellow colour in fluorescence light (Figure 14). It is assumed from the above figures that some pyrites are intimately associated with exinite and probably for this reason the specific gravity of some pyrites are lower than the pure form of pyrites.
6. Float on Specific gravity 1.50. Sulphur content 8.24 %. Similar type of pyrites shown in the previous float is shown in Figure 15 and 16, tungsten and fluorescence light respectively.

7. Float on Specific gravity 1.55. Sulphur content 9.24 %. Figure 17 (tungsten light) shows vertebra structure like pyrite which was diagenetically replaced by sulphur solution. Cellular structure in Figure 19 (tungsten light) has also been replaced by sulphur. This is probably Siderite ($FeCO_3$). They are grey with a brownish tone (in oil emersion lens) and clearly anisotropic.
8. Float on Specific gravity 1.60. Sulphur content 8.64 %. The pyrite (Figure 21, 22) associated with coal separated in this fraction look very similar to naturally occurring pyrites (Figure 42).
9. Sink in Specific gravity 1.60. Sulphur content 23.0 %. All sorts of pyritic sulphur can be observed in this fraction. In Tungsten light the pyrites can be seen as white bright without observing the exinitic structure (Figure 23). The same pyrite gave greenish fluorescence using exciting filter I and barrier filters 44/47 and faint brownish-yellow exinitic structure. Exinitic structure is not very prominent like pyrites (Figure 24). At this wave length both pyrite and exinite are observed. Using the same exciting filter I and substituting the barrier filter 47 to 53, only the exinite give the fluorescence bright yellow colour and the exinitic cells(both inside and outside the pyrites)are visible. (Figure 25). Pyrites shown in Figure 26 and 27 (tungsten and fluorescence light respectively) have similar structure which was shown in Figure 11 and 12. Some pyrites are strongly intermixed with high reflectance fusinite and sometimes it is difficult to distinguish pyrites and fusinites. (Figure 28). Only pyrites could be seen in Figure 29 by using fluorescence light. Figure 30, 31, 32 is similar to figure 23, 24 and 25. The difference between Figure 32 and Figure 25 is that large exinite structure could be seen around the pyrite.

   Dielectric Separator (Syntron) was used to separate pyrites from the Lingan coal. Following structural type of pyrites were obtained after separation.
10. The structure of pyrite shown in Figure 23 using tungsten light is practically similar to Figure 13 and 14. The only difference is that the inside black spiral structure is not exinite but probably vitrinite as shown in Figure 34 (Fluorescence light). The different structure of pyrites are shown in

Figure 35 and 37 in tungsten light and Figure 36 and 38 in fluorescence light. The structure in Figure 37 looks like pyrrholite (FeS) in Figure 43.

11. Pyrite separated by dielectric separator are shown in Figure 39, 30 and 41 and is similar to those described in Figure 30, 31 and 32.
12. The structures of pure pyrite FeS_2 and pyrrholite (FeS) are shown in Figure 42 and 43 respectively.
13. The structure of chalcopyrite is shown in Figure 44 (tungsten light) and in Figure 45 fluorescence light.
14. With No. 1 Exciting Filter and 44/47 Barrier filter pyrites fluoresces green as shown in Figure 46 and 47.

PETROGRAPHIC ANALYSIS

	F 1.25 %	F 1.30 %	F 1.35 %	F 1.40 %	F 1.45 %	F 1.50 %	F 1.55 %	F 1.60 %	S 1.60 %
Vitrinite	72.0	71.6	64.4	64.0	54.4	52.8	49.6	44.8	36.8
Fusinite	9.6	14.0	14.0	11.2	15.2	16.8	16.0	6.0	9.2
Semifusinite	0.8	0.4	0.8	2.0	1.2	2.8	2.0	0.8	2.8
Exinite	10.8	6.8	11.6	10.8	13.2	11.2	11.2	14.0	7.6
Micrinite	0.4	1.2	2.0	1.6	2.4	2.4	2.8	2.8	2.8
Mineral Matter (mostly Pyrites)	6.4	6.0	7.2	10.4	13.6	14.0	18.4	31.6	40.8
	100.	100.	100.	100.	100.	100.	100.	100.	100.
Reactives*	83.1	78.4	76.0	75.5	68.2	64.9	61.4	59.1	45.3
Inerts**	16.9	21.6	24.0	24.5	31.8	35.1	38.6	40.9	54.7
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

* Vitrinite + Exinite + 1/3 Semifusinite.

** Fusinite + 2/3 Semifusinite + Micrinite + Mineral Matter.

TABLE I

Sample Number:	3208-72		3209-72		3210-72		3211-72		3212-72	
Sample Mark:	B-285-72		B-285-72 (A)		B-285-72 (B)		B-285-72 (C)		B-285-72 (D)	
Specific Gravity Fraction	Raw Coal		F 1.25		F 1.30		F 1.35		F 1.40	
	As Rec'd	Dry	As Rec'd	Dry	As Rec'd	Dry	As Rec'd	Dry	As Rec'd	Dry
Proximate Analysis										
Moisture ..... %	2.50	0.00	2.58	0.00	3.23	0.00	2.22	0.00	2.16	0.00
Ash..... %	6.26	6.42	1.06	1.09	2.20	2.27	5.43	5.55	8.26	8.44
Volatile Matter ..... %	37.62	38.58	38.84	40.07	37.22	38.46	37.42	38.27	37.20	38.02
Fixed Carbon (By Difference)..... %	53.62	55.00	56.52	58.84	57.35	59.27	54.93	56.18	52.38	53.54
Ultimate Analysis										
Carbon ..... %	76.02	77.97	81.29	83.44	80.50	83.19	77.81	79.58	73.95	75.58
Hydrogen ..... %	5.14	5.27	5.59	5.74	5.38	5.56	5.19	5.31	4.94	5.05
Sulphur ..... %	2.35	2.41	0.65	0.67	0.89	0.92	2.94	3.01	4.70	4.87
Nitrogen ..... %	1.62	1.66	1.79	1.84	1.71	1.77	1.66	1.70	1.52	1.55
Ash ..... %	6.26	6.42	1.06	1.09	2.20	2.27	5.43	5.55	8.26	8.44
Oxygen (By Difference ..... %	6.11	6.27	7.04	7.22	6.09	6.29	4.75	4.85	4.41	4.51
Calorific Value										
Btu/lb Gross	13670	14020	14580	14960	14330	14810	13860	14180	13430	13730
Swelling Properties										
Free Swelling Index (ASTM)	N/D		5		5		6 1/2		5	
Ash Fusibility										
Initial Deformation °F	N/D		1950		2010		2050		2075	
Softening - Spherical °F			2130		2140		2230		2220	
Softening - Hemispherical °F			2200		2230		2240		2250	
Fluid °F			2550		2510		2340		2320	
Sulphur Forms										
Sulphate	N/D		0.00		0.02		0.04		0.0[illegible]	
Pyritic			0.13		0.35		2.11		3.61	
Organic (By difference)			0.52		0.52		0.79		1.09	
Total			0.65		0.89		2.94		4.76	
[illegible]	N/D		0.275		0.20		0.19		0.17	

Sample Number:	3213-72		3214-72		3215-72		3216-72		3217-72	
Sample Mark:	B-285-72 (E)		B-285-72 (F)		B-285-72 (G)		B-285-72 (H)		B-285-72 (I)	
Specific Gravity Fraction	F 1.45		F 1.50		F 1.55		F 1.60		S 1.60	
	As Rec'd	Dry	As Rec'd	Dry	As Rec'd	Dry	As Rec'd	Dry	As Rec'd	Dry
Proximate Analysis										
Moisture ..... %	2.01	0.00	1.95	0.00	1.74	0.00	1.65	0.00	1.24	0.00
Ash..... %	12.15	12.40	14.55	14.84	16.31	16.60	18.61	18.92	31.05	31.45
Volatile Matter ..... %	36.94	37.70	34.47	35.16	33.07	33.66	30.42	30.93	28.24	28.59
Fixed Carbon (By Difference)..... %	48.90	49.90	49.03	50.00	48.88	49.74	49.32	50.15	39.46	39.96
Ultimate Analysis										
Carbon ..... %	70.45	71.90	67.20	68.54	67.03	68.22	66.07	67.18	31.64	32.04
Hydrogen ..... %	4.71	4.81	4.38	4.47	4.27	4.35	3.97	4.04	2.02	2.05
Sulphur ..... %	6.76	6.90	8.08	8.24	9.08	9.24	8.50	8.64	22.67	22.95
Nitrogen ..... %	1.52	1.55	1.32	1.35	1.28	1.30	1.13	1.15	0.43	0.44
Ash ..... %	12.15	12.40	14.55	14.84	16.31	16.60	18.61	18.92	31.05	31.45
Oxygen (By Difference ..... %	2.40	2.44	2.52	2.56	0.29	0.29	0.07	0.07	10.94	11.07
Calorific Value										
Btu/lb Gross	12830	13090	12520	12770	12030	12240	11970	12170	5810	5940
Swelling Properties										
Free Swelling Index (ASTM)	5		4 1/2		2 1/2		1		1/2	
Ash Fusibility										
Initial Deformation °F	2000		2300		2060		1980		2050	
Softening - Spherical °F	2250		2350		2260		2150		2100	
Softening - Hemispherical °F	2300		2390		2310		2200		2120	
Fluid °F	2400		2420		2600		2520		2150	
Sulphur Forms										
Sulphate	0.11		0.15		0.15		0.13		0.38	
Pyritic	5.23		6.12		6.48		5.42		21.93	
Organic (By difference)	1.42		1.81		2.45		1.90		0.46	
Total	6.76		8.08		9.08		8.50		22.67	
Chlorine	0.17		0.16		0.14		0.15		0.11	

Table II

PERCENTAGE RECOVERY OF FLOAT-SINK FRACTIONS

Lab No.	Sample Mark	Float - Sink	%
3138-72	B-285-72	-	-
3209-72	B-285-72 (A)	F. 1.25	46.60
3210-72	B-285-72 (B)	F. 1.30	31.73
3211-72	B-285-72 (C)	F. 1.35	5.83
3212-72	B-285-72 (D)	F. 1.40	3.58
3213-72	B-285-72 (E)	F. 1.45	1.91
3214-72	B-285-72 (F)	F. 1.50	1.53
3215-72	B-285-72 (G)	F. 1.55	1.06
3216-72	B-285-72 (H)	F. 1.60	0.68
3217-72	B-285-72 (I)	S. 1.60	8.08
			100.00

Ash Analysis

No.	3209-72	3210-72	3211-72	3212-72	3213-72	3214-72	3215-72	3216-72	3217-72
Mark	B-285-72(A)	B-285-72(B)	B-285-72(C)	B-285-72(D)	B-285-72(E)	B-285-72(F)	B-285-72(G)	B-285-72(H)	B-285-72(I)
	F 1.25	F 1.30	F 1.35	F 1.40	F 1.45	F 1.50	F 1.55	F 1.60	S 1.60
	%	%	%	%	%	%	%	%	%
	32.26	28.32	12.17	9.96	12.57	9.66	11.95	13.79	12.41
Al_2O_3	25.07	23.89	9.09	8.99	9.70	8.76	10.05	10.47	7.01
Fe_2O_3	22.42	31.12	63.65	70.78	67.03	69.98	61.70	55.49	55.04
TiO_2	-	-	-	-	-	-	-	-	-
	1.78	0.92	0.25	0.34	0.46	0.34	0.19	0.17	0.20
	0.72	0.55	0.21	0.22	0.22	0.18	0.21	0.22	0.23
	6.60	6.44	6.37	4.30	4.10	4.09	6.30	7.35	10.92	
	0.91	0.98	0.30	0.30	0.24	0.27	0.25	0.00	0.37
	5.82	6.33	6.30	4.23	4.66	4.32	8.17	10.04	13.01
Mn_2O	2.62	1.07	0.44	0.24	0.19	0.15	0.19	0.15	0.15
K_2O	0.88	0.66	0.26	0.29	0.37	0.15	0.22	0.44	0.44

Fig. 1. 1.25 Sp gr float, S content 0.67 %

Fig. 2. Same as Fig. 1.

Fig. 3. 1.30 Sp gr float S content 0.92 %.

Fig. 4. Same as Fig. 3. S content 0.92

Fig. 5. 1.35 Sp gr float S content 3.01

Fig. 6. 1.40 Sp gr float S content 4.87

Fig. 7. Same as Fig. 6

Fig. 8. Same as Fig. 7

Fig. 9. 1.45 Sp gr float S content 6.96 Tungsten light

Fig. 10 Same as Fig. 9 Fluorescence light 47/44 EG1.

Fig. 11 1.45 Sp gr float S content 0.96 Tungsten light.

Fig. 12 Same as Fig. 11 S content 6.90 Fluorescence light. 47/44 EG1.

Fig. 13 1.45 Sp gr float S content 6.90 Tungsten light.

Fig. 14 Same as Fig. 13 Fluorescence light. 47/44.

Fig. 15 1.50 Sp gr float S content 8.24 Tungsten light

Fig. 16 Same as Fig. 15 Fluorescence light.

Fig. 17 1.55 Sp gr float S content 9.24 Tungsten light.

Fig. 18 Same as Fig. 17

Fig. 19 1.55 Sp gr float S content 9.24 Tungsten light

Fig. 20 Same as Fig. 19 Fluorescence light 47/44 EG1.

Fig. 21 1.60 Sp gr float Fluorescence S 8.67

Fig. 22 1.60 Sp gr float Fluorescence S 8.67

Fig. 23 1.60 Sp gr Sink S.230 Tungsten light

Fig. 24 1.60 Sp gr Sink S.230 Fluorescence 47/46 EG1.

Fig. 25 1.60 Sp gr Sink S.230 Fluorescence 44/55

Fig. 26 1.60 Sp gr Sink S.230 Tungsten light

Fig. 27 1.60 Sp gr Sink S.230 Fl. light 47/44

Fig. 28 1.60 Sp gr Sink S.230 Tungsten light intermixing of coal + pyrites &

Fig. 29 1.60 Sp gr Sink S.230 Fl. Light

Fig. 30 1.60 Float S.8.66 Tungsten

Fig. 31 1.60 Float S.8.66 Fl. 47/44

Fig. 32 1.60 Float S.8.64 Fl. 50/44

Fig. 33 Pyrites from dielectric separator. Tungsten light

Fig. 34 Pyrites from dielectric separator. Fluorescence light

Fig. 35 Pyrites cluster shape from dielectric separator. Tungsten light

Fig. 36 Pyrites cluster shape from dielectric separator - Fluorescence light.

Fig. 37 Pyrites looks like Pyrrholite - Tungsten light without exinitic structure

Fig. 38 Pyrites looks like Pyrrholite - Fluorescence light without exinitic structure

Fig. 39 Pyrites with exinite inclusion - Tungsten light

Fig. 40 Pyrites with exinite inclusion - Fluorescence light exciting Filter I, Barrier filter 47/44

Fig. 41 Pyrites with exinite & Ex. Filter 1. B.F. 53/44

Fig. 42 Pyrites (pure) in Tungsten light

Fig. 43 Pyrrholite (FeS) in Tungsten light

Fig. 44 Calchopyrite in Tungsten light

Fig. 45 Calchopyrite in Tungsten light

Fig. 46 Pyrites from coal in Fluorescence light Ex. Filter 1, B.F. 47/44

Fig. 47 Pyrites from coal in Fluorescence light Ex. Filter 1, B.F. 47/44

Fig. 1. 1.25 Sp gr float, S content 0.67 %

Fig. 2. Same as Fig. 1.

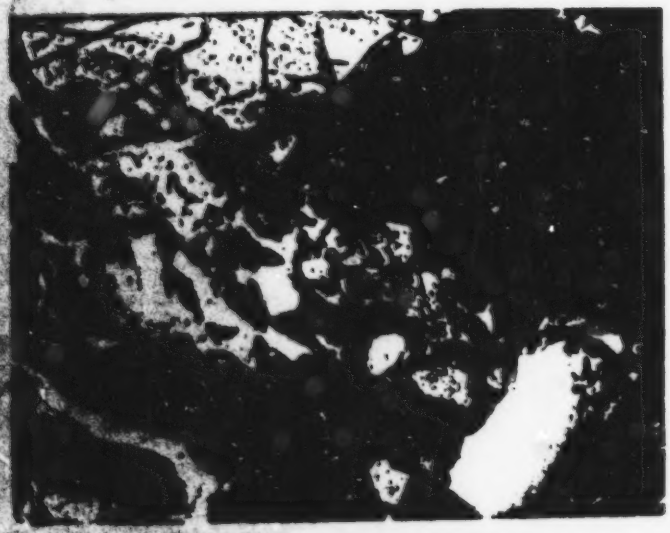

Fig. 3. 1.30 Sp gr float S content 0.92 %.

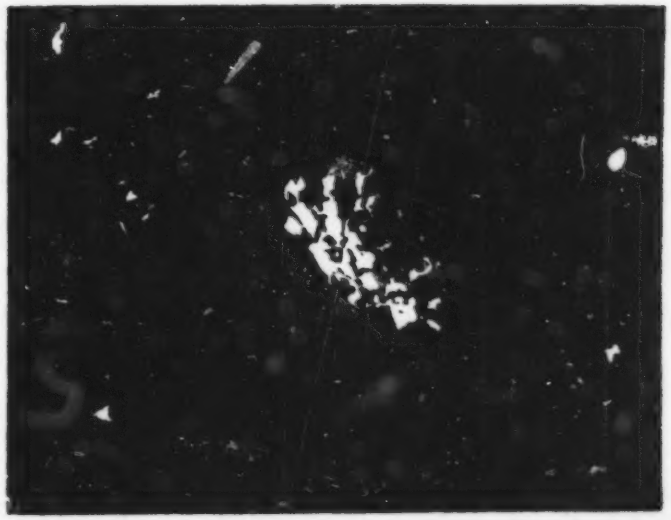

Fig. 4. Same as Fig. 3. S content 0.92

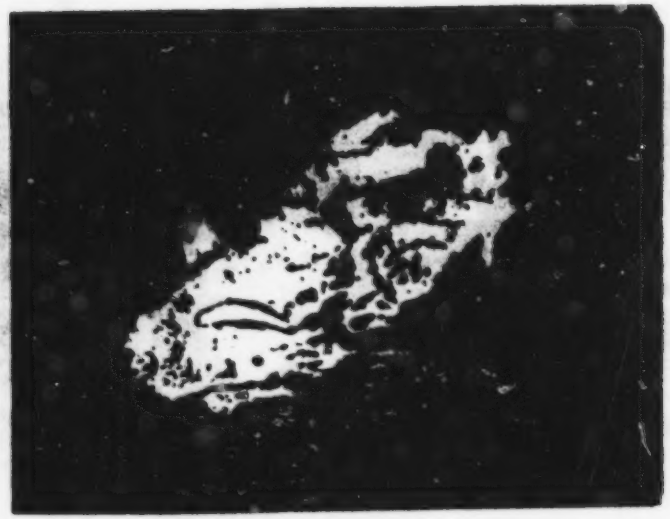

Fig. 5. 1.35 Sp gr float S content 3.01

Fig. 6. 1.40 Sp gr float S content 4.87

Fig. 7. Same as Fig. 6

Fig. 8. Same as Fig. 7

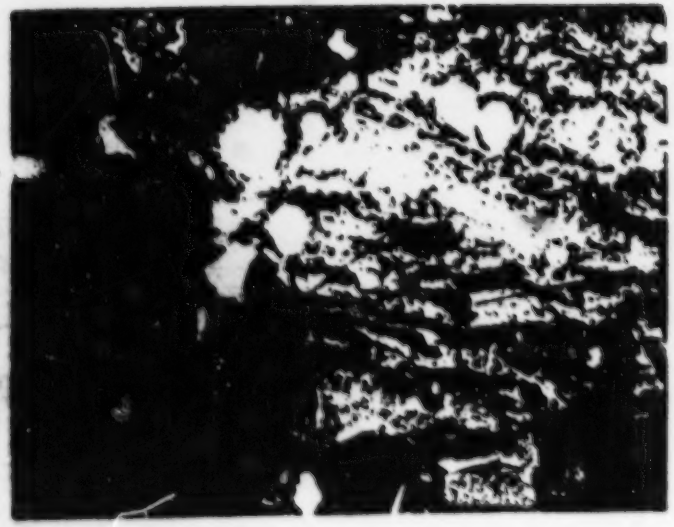

Fig. 9. 1.45 Sp gr float
S content 6.96 Tungsten light

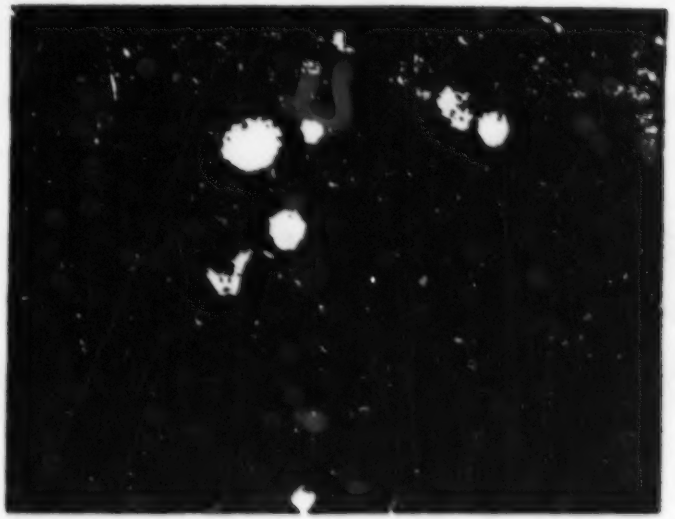

Fig. 10 Same as Fig. 9
Fluorescence light 47/44 EGl.

Fig. 11 1.45 Sp gr float

Fig. 12 Same as Fig. 11

Fig. 13 1.45 Sp gr float
S content 6.90 Tungsten light.

Fig. 14 Same as Fig. 13
Fluorescence light. 47/44.

Fig. 15 1.50 Sp gr float

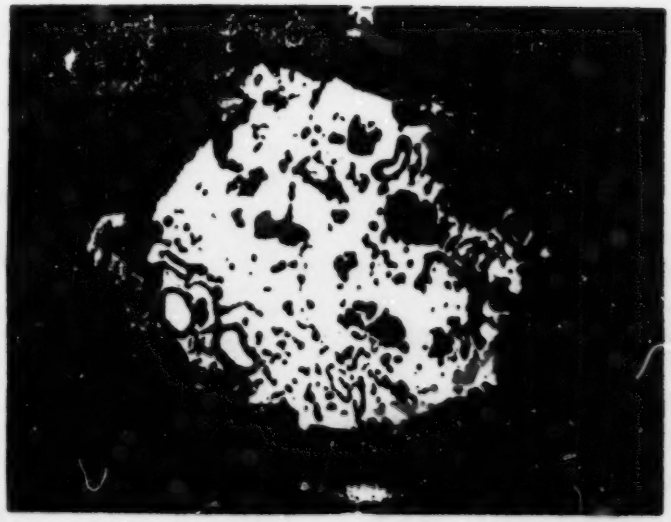

Fig. 16 Same as Fig. 15

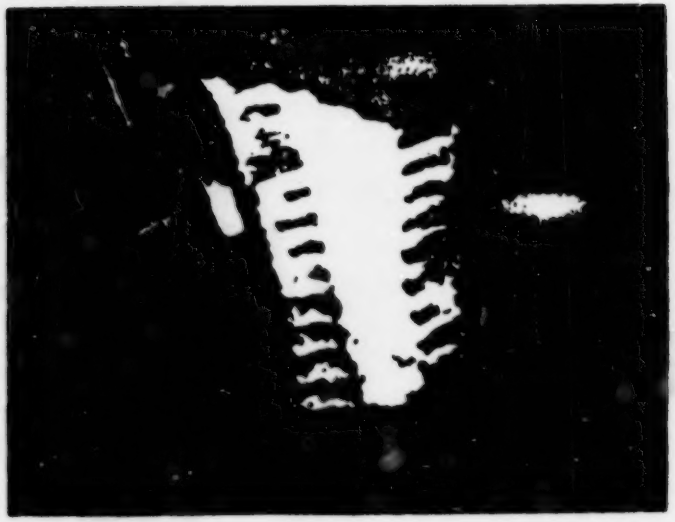

Fig. 17 1.55 Sp gr float

S content 9.24 Tungsten light.

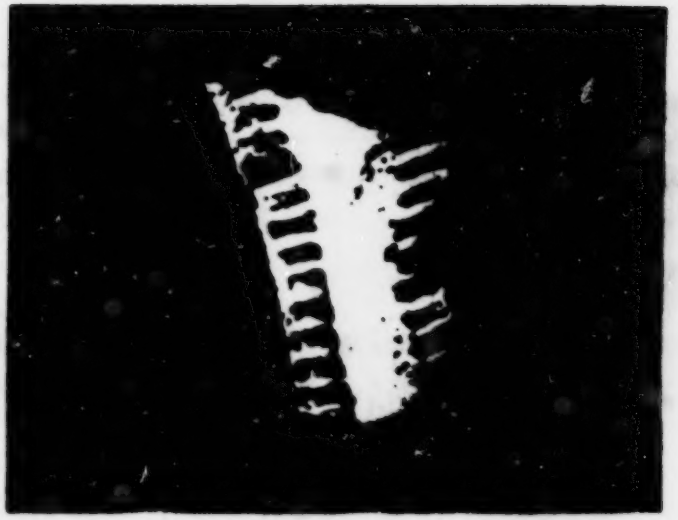

Fig. 18 Same as Fig. 17

Fig. 19 1.55 Sp gr float

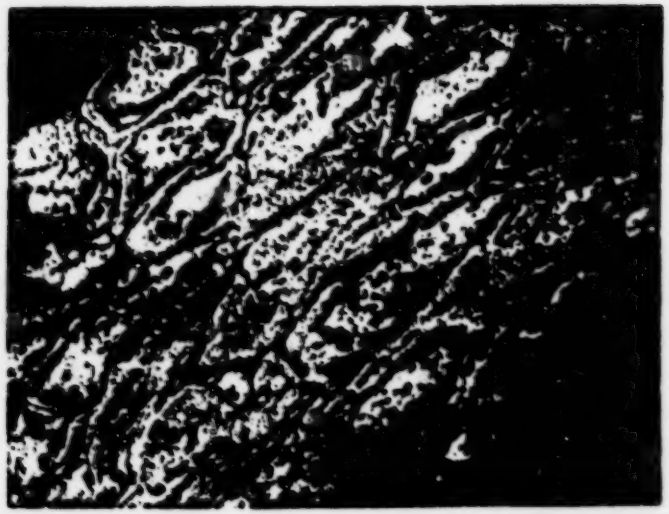

Fig. 20 Same as Fig. 19

Fig. 21 1.60 Sp gr float Fluorescence S 8.67

Fig. 22 1.60 Sp gr float Fluorescence S 8.67

Fig. 23 1.60 Sp gr Sink S.230 Tungsten light

Fig. 24 1.60 Sp gr Sink S.230
Fluorescence 47/46 EGl.

Fig. 25 1.60 Sp gr Sink S.230 Fluorescence 44/55

Fig. 26 1.60 Sp gr Sink S.230 Tungsten light

Fig. 27 1.60 Sp gr Sink S.230 Fl. light 47/44

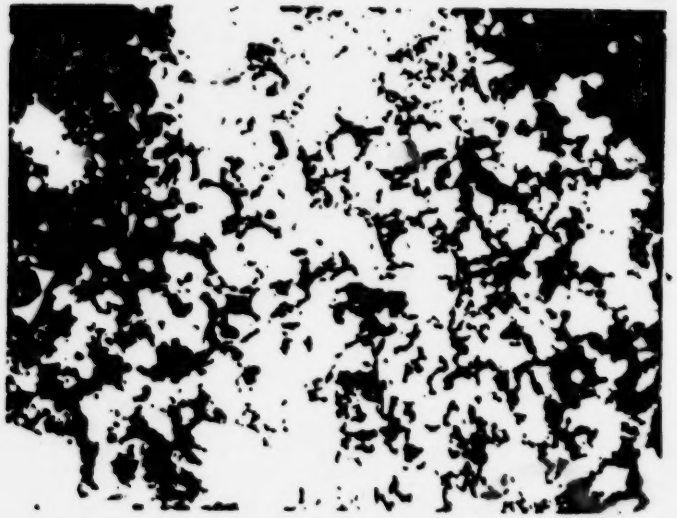

Fig. 28 1.60 Sp gr Sink S.230

Fig. 29 1.60 [illegible] light

Fig. 30 1.60 Float S.8.64 Tungsten

Fig. 31 1.60 Float S.8.64 Fl. 47/44

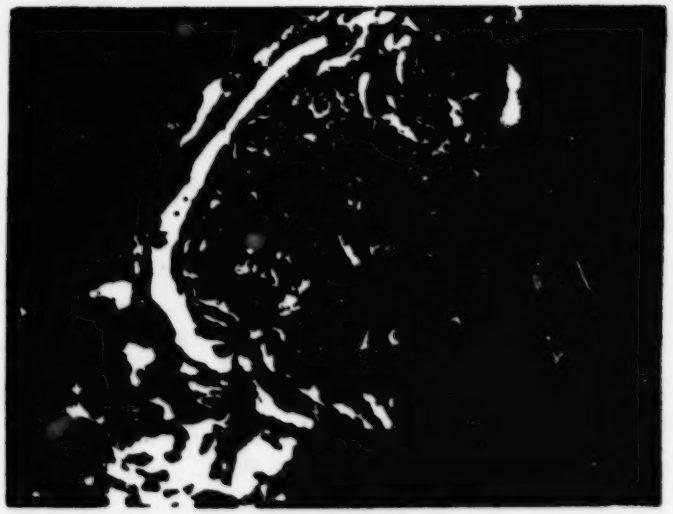

Fig. [illegible] 1.60 Float S.8.64 [illegible]

Dielectric Separator

Fig. 33 Pyrites from dielectric separator.
Tungsten light

Fig. 34 Pyrites from dielectric separator.
Fluorescence light

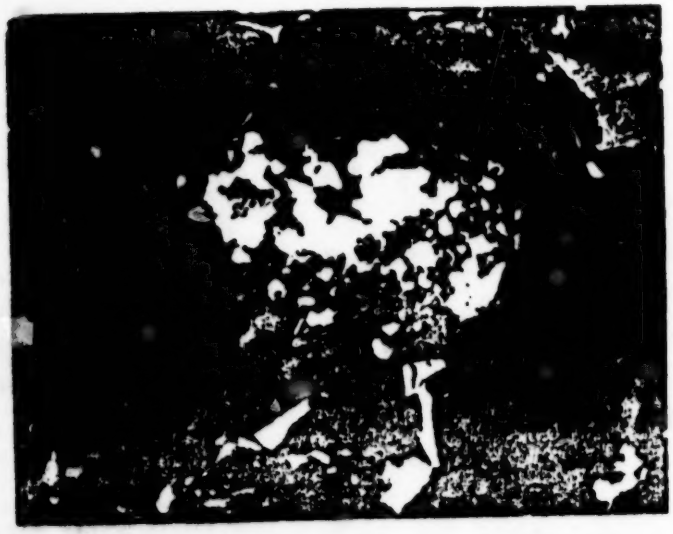

Fig. 35 Pyrites cluster shape from dielectric separator. Tungsten light

Fig. 36 Pyrites cluster shape from dielectric separator - Fluorescence light.

Fig. 37 Pyrites looks like Pyrrhotite - Tungsten light without exinitic structure

Fig. 38 Pyrites looks like Pyrrhotite - Fluorescence light without exinitic structure

Fig. 39 Pyrites with exinite inclusion - Tungsten light

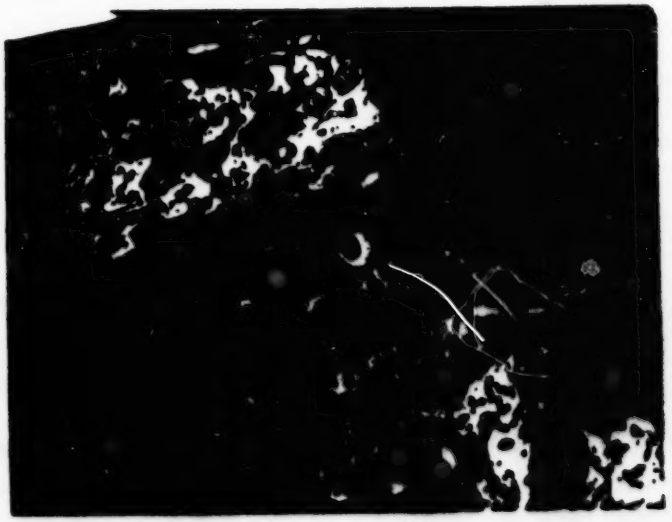

Fig. 40 Pyrites with exinite inclusion - Fluorescence light exciting Filter I, Barrier filter 47/44

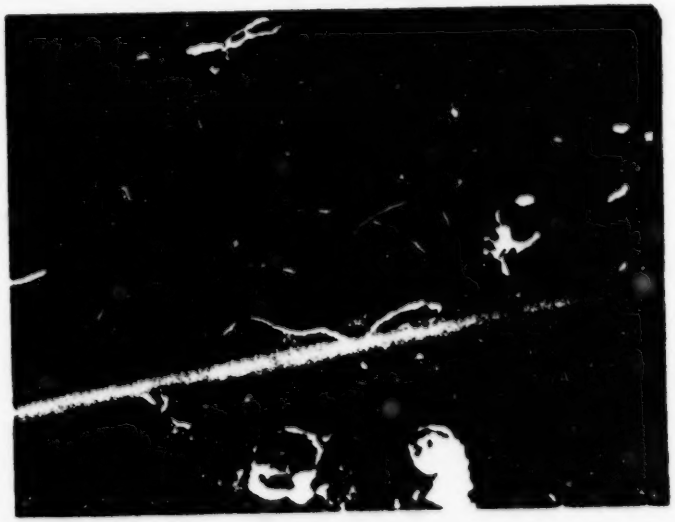

Fig. 41 Pyrites with exinite [illegible] Filter I. B.F. 53/44

Fig. 42 Pyrites (pure) in Tungsten light

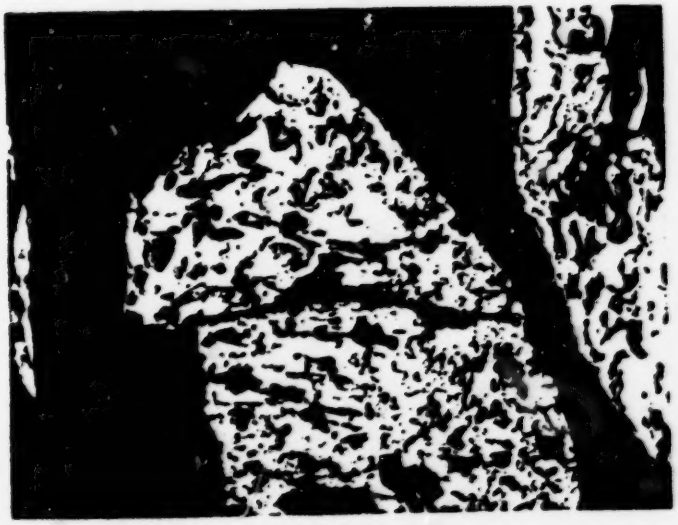

Fig. 43 Pyrrholite (FeS) in Tungsten light

Fig. 44 Calchopyrite in Tungsten light

Fig. 45 Calchopyrite in Tungsten light

Fig. 46 Pyrites from coal in Fluorescence light Ex. Filter 1, B.F. 47/44

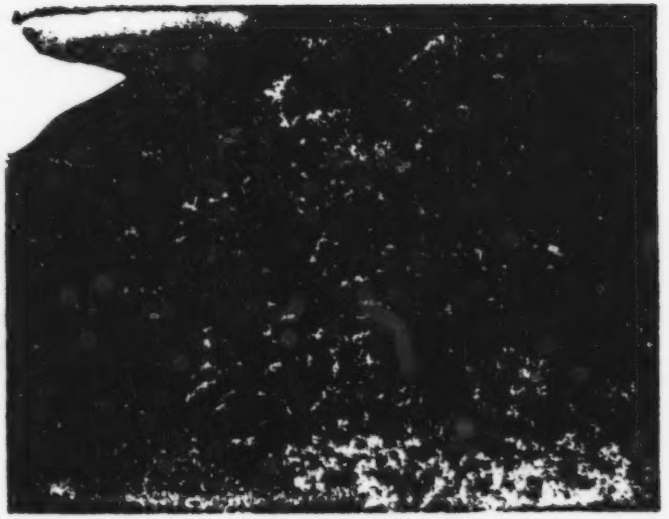

Fig. 47 Pyrites from coal in Fluorescence light Ex. Filter 1, B.F. 47/44

POOR

QUALITY

ORIGINAL